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Timber Fuel-Breaks and Fuel Moisture

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ABSTRACT: Four study areas to represent timber fuel-breaks with 20, 40, 60, and 80 percent crown closures were selected on the Stanislaus National Forest in central California. Fuel moisture at each area was measured by standard indicator sticks. The results suggest that up to 80 percent of the overstory can be thinned without affecting fuel moisture on the ground if a living ground cover of low flammability can be established.

Fuel-breaks are strategically located strips of land on which fuel hazard has been greatly reduced by thinning and slash disposal to aid fire control efforts. In timber stands, hazard reduction means that saplings and poles may have to be thinned and leave trees pruned to keep fires from crowning out.

In building fuel-breaks, the forester or fireman must decide how to thin. If he thins too little, fires may escape across the fuel-break; if he thins too much, the climate near the ground may be changed. Reports in the literature show that such changes may result in higher temperatures, lower fuel moisture, and greater number of days when disastrous crown fires can break out.[1,2]

In a trial at the Stanislaus National Forest, in central California, we found that within the range of fuel moistures investigated, thinning as much as 80 percent of the crown cover did not appreciably affect fuel moisture. These findings can serve as guidelines for future fuel-break planning and building.

Levels of Crown Closure

A team of foresters and forest firemen conducted a field survey to decide on preliminary needs for thinning fuel-breaks in timber. The team decided that in typical ponderosa pine (Pinus ponderosa Laws.) stands on the west side of the Sierra Nevada crown closure ranging between 20 and 80 percent density would be necessary to achieve a balance between timber management objectives and successful fire control.

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[1] Countryman, C. M. Old-growth conversion also converts fire climate. Soc. Amer. Foresters Proc. 1955: 158-160. 1955.

[2] Geiger, Rudolph. Climate near the ground. p. 97. Cambridge: Harvard Univ. Press. (Transl. 2nd German ed.)

Figure 1.--Building of fuel-breaks can change fuel moistures near the ground. The section of fuel-break in the middle here has about a 20-percent crown closure.

Several fire weather factors can be affected by fuel-break thinning levels. Fuel moisture was chosen for study because it is an important element of fire danger.

A section of ridgetop in mature ponderosa pine, medium pine reproduction, and brush which was fire fuel type 6[3], and exposed to the prevailing winds and weather, was chosen for the test site. Elevation, aspect, and terrain and fuel were nearly constant over the 4.5-chain section and differences due to these factors were taken to be negligible. Crews selected four fuel-break study areas with crown closure densities of 80 percent, 60 percent, 40 percent, and 20 percent (fig. 1). Crown closure was measured by a specially constructed viewer with 2-inch grids. Each study area was 1 chain long (with the ridge) and 300 feet wide. A one-half chain buffer strip separated each area.

Slash and brush, chiefly manzanita (Arctostaphylos sp.), were removed from within each study area and standing trees were pruned to 10 feet to conform to standard fuel-break design for the area. The ground cover, consisting of bear clover (Chamaebatia foliolosa), was left intact.

Four standard fuel-moisture sticks were placed at random over each study area. The sticks were hung 12 inches above the ground--at least 6 inches above living ground cover. Temperature, relative humidity, and wind speed and direction were taken by manual readings each time the sticks were weighed. Precipitation was recorded by a rain gauge placed next to the study area.

[3]Forest Service, U.S. Dep. Agr. Fire line notebook. California Region, 1960. p. 2.

Whenever possible, fuel moisture and weather readings were taken daily in the morning (8-11 a.m.), noon (11 a.m.-2 p.m.), and afternoons (2-5 p.m.) during the 1962 and 1963 fire seasons. The study area was 25 miles from the nearest field station; regular daily readings were not possible. The sticks were rotated after each weighing to reduce variability due to stick differences. At the end of the second fire season, 1963, the readings were compiled and the replicated fuel moisture readings for each area were averaged and broken down by times of day.

The distributions were distinctly anormal in form, being significantly positively skewed (g-statistics) even after a logarithmic transformation. The data were transformed to the log-log form for variance and regression analyses (table 1). Predicted values were retransformed to the original scale for plotting.

Table 1.--*Analysis of variance of fuel moisture based on log-log transformation of average fuel moistures*

Variation due to	Degrees of freedom	Mean square	F	$F_{.05}$	$F_{.01}$
AFTERNOON					
Treatments:	(3)				
Linear	1	0.047385	2.11	3.85	6.66
Quadratic	1	.011534	< 1	3.85	6.66
Cubic	1	.045781	2.03	3.85	6.66
Error	840	.022498	--	--	--
NOON					
Treatments:	(3)				
Linear	1	.150961	16.12	3.91	6.81
Quadratic	1	.004403	< 1	3.91	6.81
Cubic	1	.000289	< 1	3.91	6.81
Error	191	.009366	--	--	--

The data showed that noon fuel moistures were inversely proportional to crown cover (fig. 2), but there was no significant trend in afternoon fuel moistures as crown cover changed (fig. 3).

Results and Discussion

Perhaps the denser crown closure intercepted more rainfall. Rainstorms occurred during early summer and each fall before fire season was officially declared over. Separation of the data according to rain and no-rain days showed that fuel moisture still appeared to decrease as crown closure increased (fig. 4), but the differences were not statistically significant.

To determine if the averages could hide potentially important relationships, we separated the data according to air temperature, relative humidity, and wind speed readings (fig. 5). Again, this separation showed no significant differences in fuel moisture.

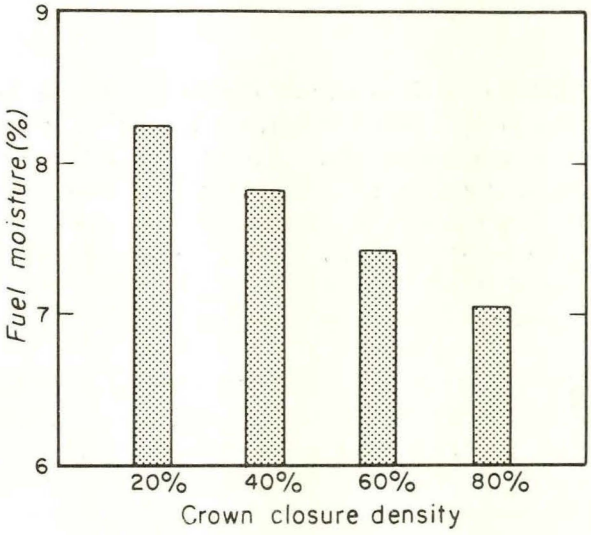

Figure 2.--Average fuel moistures, by crown closure classes--noon, 1962-63.

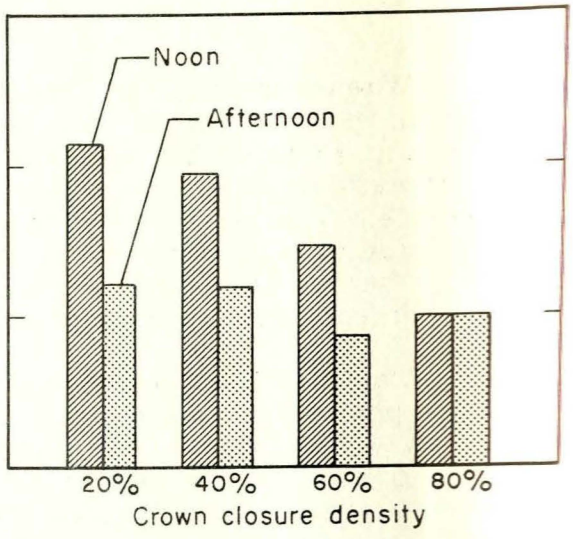

Figure 3.--Average fuel moistures, by crown closure classes--noon and afternoon readings 1962-63.

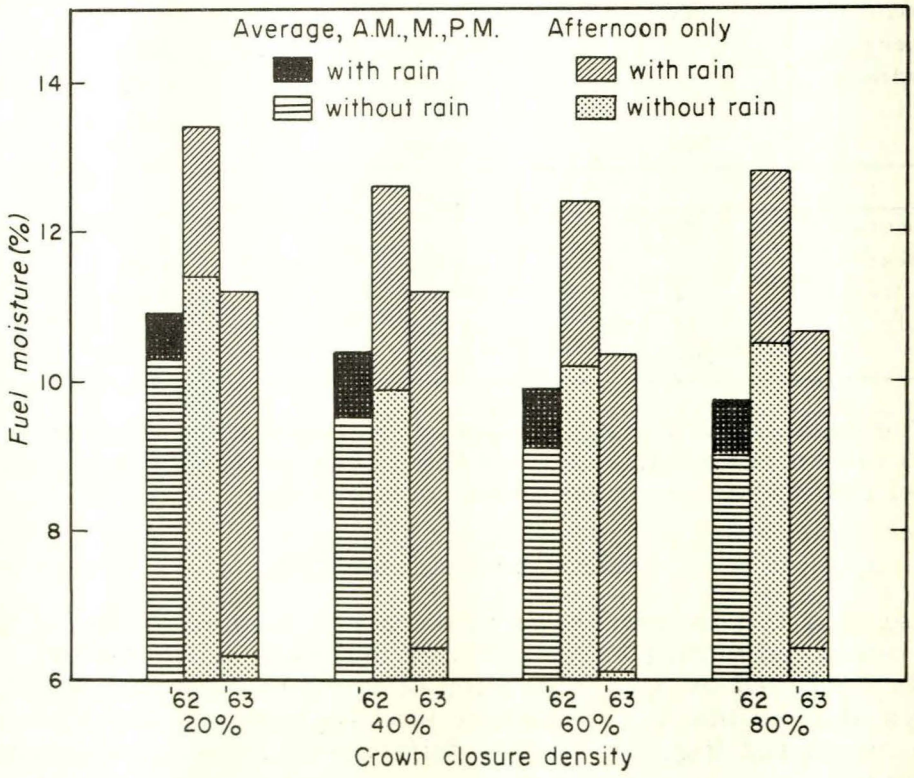

Figure 4.--Average fuel moistures, by crown closure classes, average of all readings, 1962, and afternoon readings, 1963.

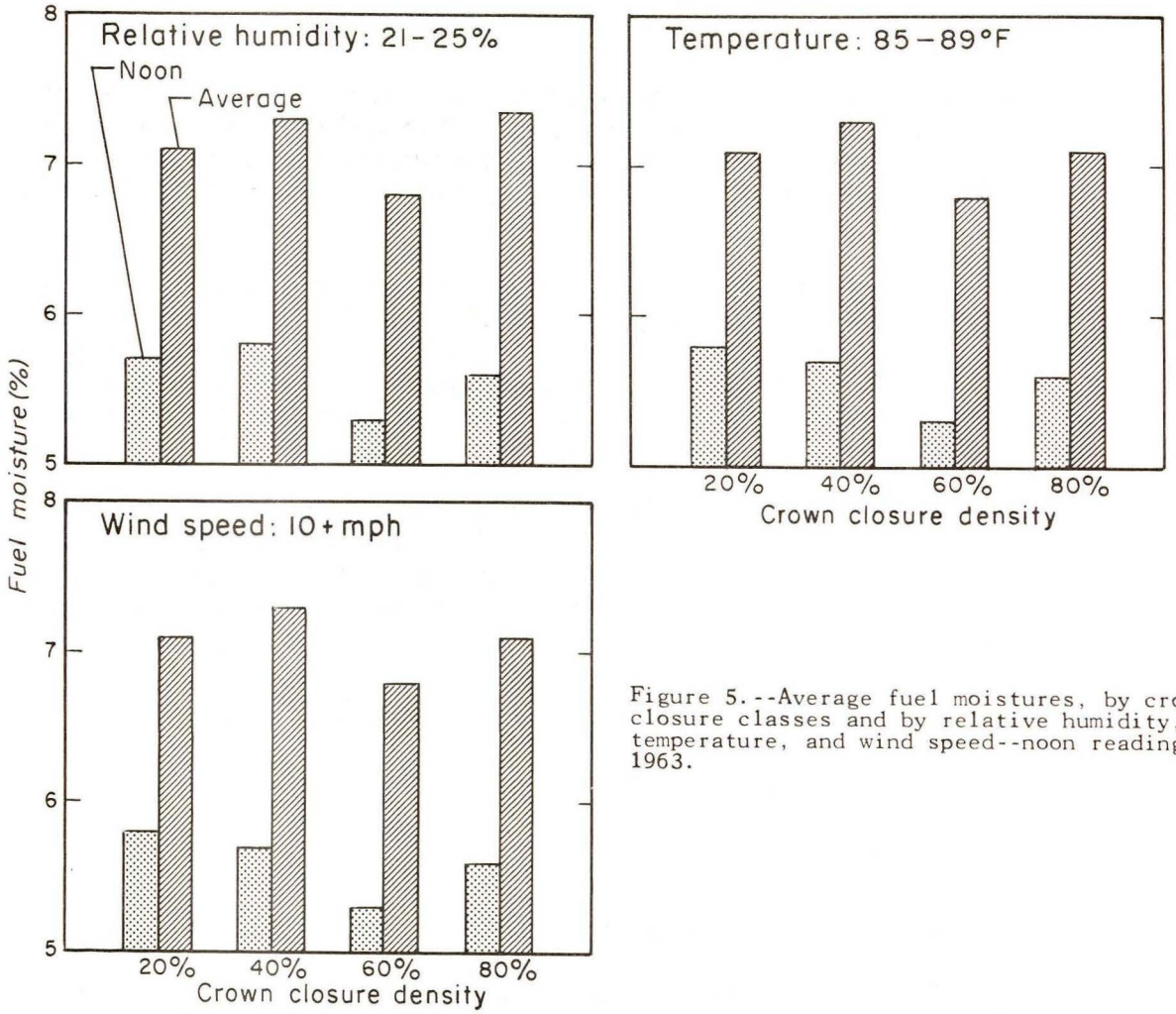

Figure 5.--Average fuel moistures, by crown closure classes and by relative humidity, air temperature, and wind speed--noon readings, 1963.

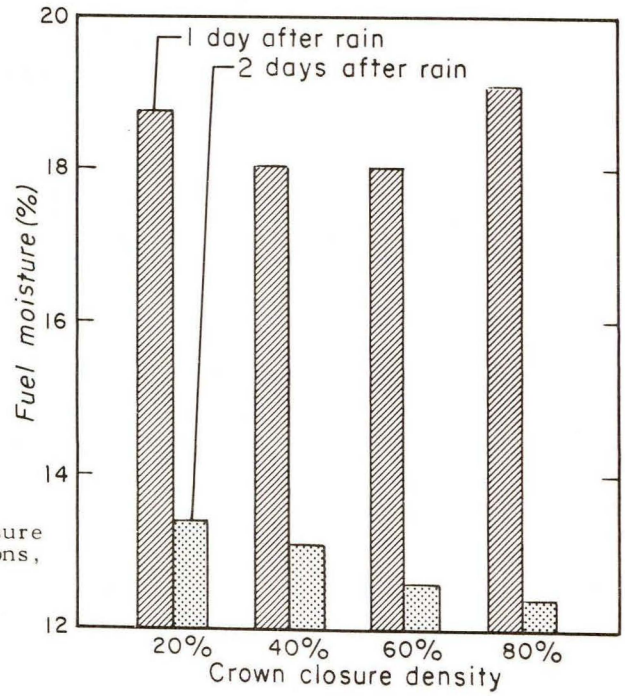

Figure 6.--Average fuel moistures, by crown closure classes, 1 and 2 days after rain in the afternoons, 1962-63.

Finally the data were separated by days after rain to see if living ground fuel dried out sooner under open cover and thus might reduce the effectiveness of a fuel-break. But this premise was not supported by data relating fuel moisture 1 and 2 days after rain to crown closure (fig. 6).

Why fuel moisture differed so little may be explained by Tappeiner's work.[4] He showed that the "drying power of the air"--defined as the combination of the drying effects of temperature, relative humidity, and wind--over shaded bear clover was one-fourth that over open bare ground. Tappeiner attributed this partly to the high transpiration rate of bear clover and to the depth and density of its root system.

Bear clover was the dominant live ground cover on the study areas. Its density was determined for each fuel-break study areas by gridding each area and estimating percentage densitites; density was then compared with the fuel moisture readings. Relation of crown closure to ground cover was as follows:

Crown closure	Ground cover
- - - -(percent)- - -	
80	0
60	35
40	40
20	80

Fuel moisture was directly proportional to the density of live ground cover.

We concluded that fuel-breaks in typical ponderosa pine types on the west side of the Sierra Nevada can be constructed and maintained by thinning as much as 80 percent of the overstory without appreciably affecting fuel moistures near the ground if a living ground cover can be established. To aid fire control, this cover should be of relatively low flammability, as is bear clover.

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[4] Tappeiner, John C. II. A contribution to the study of the ecology of Squaw Carpet (Ceanothus prostratus) as relevant to the establishment and growth of conifer reproduction at Blodgett Forest. 1961. (Unpublished master's thesis on file at Univ., Calif., Berkeley, Calif.)